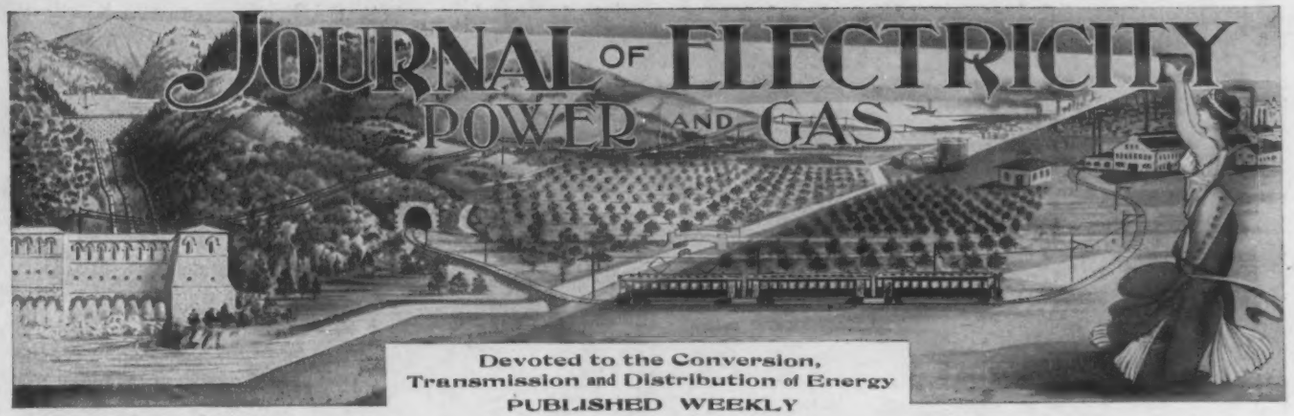

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THE

Journal of Electricity, Power and Gas

Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XX. SAN FRANCISCO, CAL., FEBRUARY 29, 1908 No. 9

HIGH HEAD FRANCIS TURBINE AT CENTERVILLE POWER PLANT.

Mr. Jas. H. Wise, assistant hydraulic engineer of the California Gas and Electric Corporation, read a paper on the "Centerville Hydro-Electric Power Installation of the California Gas and Electric Corporation," at the bi-monthly meeting of the San Francisco Association of the American Society of Civil Engineers, on Friday, February 21, 1908. In the course of the reading, and in the discussion that followed, Mr. Wise described the head works, canal, pipe line, power plant and turbine of this installation as is summarized below. It includes a description of the highest head Francis turbine yet installed, a 9,700 horsepower unit under an effective head of 565 feet, and direct connected to a 5,500-kilowatt generator. works, canal, pipe line, power plant and turbine of this installation as is summarized below. It includes a description of the highest head Francis turbine yet installed, a 9,700 horsepower unit under an effective head of 565 feet, and direct connected to a 5,500-kilowatt generator.

The Centerville power plant is operated in parallel with the ten other hydro-electric plants of this corporation, as well as with their three steam plants and the gas engine set at Martin's station. These give a total of 133,132 available horsepower, of which an output of 93,150 is obtained from the hydro-electric plants. The location of all these is best shown by the accompanying map, the Centerville plant being thirteen miles northeast of Chico. It feeds directly on to the line leading from De Sabla, and the two plants are run in parallel with the rest of the system. A description of the De Sabla plant, together with a paper by Mr. F. G. Baum, on "High Potential Long Distance Transmission and Control," appeared in the "Journal of Electricity, Power and Gas," of November, 1904.

Centerville makes a second use of the water supplied De Sabla. This is taken mainly from Butte Creek, having a capacity of three thousand inches, by the Cherokee ditch, supplemented by 3,000 inches more from the Hendricks ditch, the latter being brought over from the west branch of the Feather River. After operating the De Sabla power plant, this water is again taken out, one-fourth of a mile below, and is carried 8.3 miles by ditch and flume to Centerville. Diversion is secured by means of a cyclopean concrete dam 15 feet high, 3 feet wide on the crest, and 90 feet long, which is arched up stream. This canal consists of 6.7 miles of ditch and 1.6 miles of flume. It has been reconstructed from an old mining ditch, having a capacity of 45 second feet, so as to deliver 175 second feet. Full details of this work will be given in an early issue of the "Journal," it being a digression from the main topics here discussed.

The canal terminates in a reinforced concrete forebay, 18x25x20 feet, three hundred feet above which is a settling basin and grizzly. One 36-inch and 42-inch pipe of riveted steel, and two 24-inch pipes lead from the forebay 2,566 feet to the power house, where they are all connected by means of a multiple casting which delivers water to a 900-kilowatt impulse unit and to a 5,500-kilowatt turbine unit, the latter being connected by means of a 45-inch gate and taper piece to this "Y" casting, which is the confluence of these three pipes.

The Centerville plant started running in December, 1902, the original installation consisting of one 900-kilowatt and two 400-kilowatt units, all impulse wheels operating under a static head of 577 feet. The two 400-kilowatt units have been replaced recently by a 5,500-kilowatt Francis turbine, occupying the same floor space. For the new installation the concrete walls of the power house were raised and steel roof trusses substituted for the wooden ones. The accompanying interior view shows that at one end of the building there is a transformer room, and at the other end the machine shop, and between these the generating units. The building stands on a solid sandstone foundation, and is fireproof.

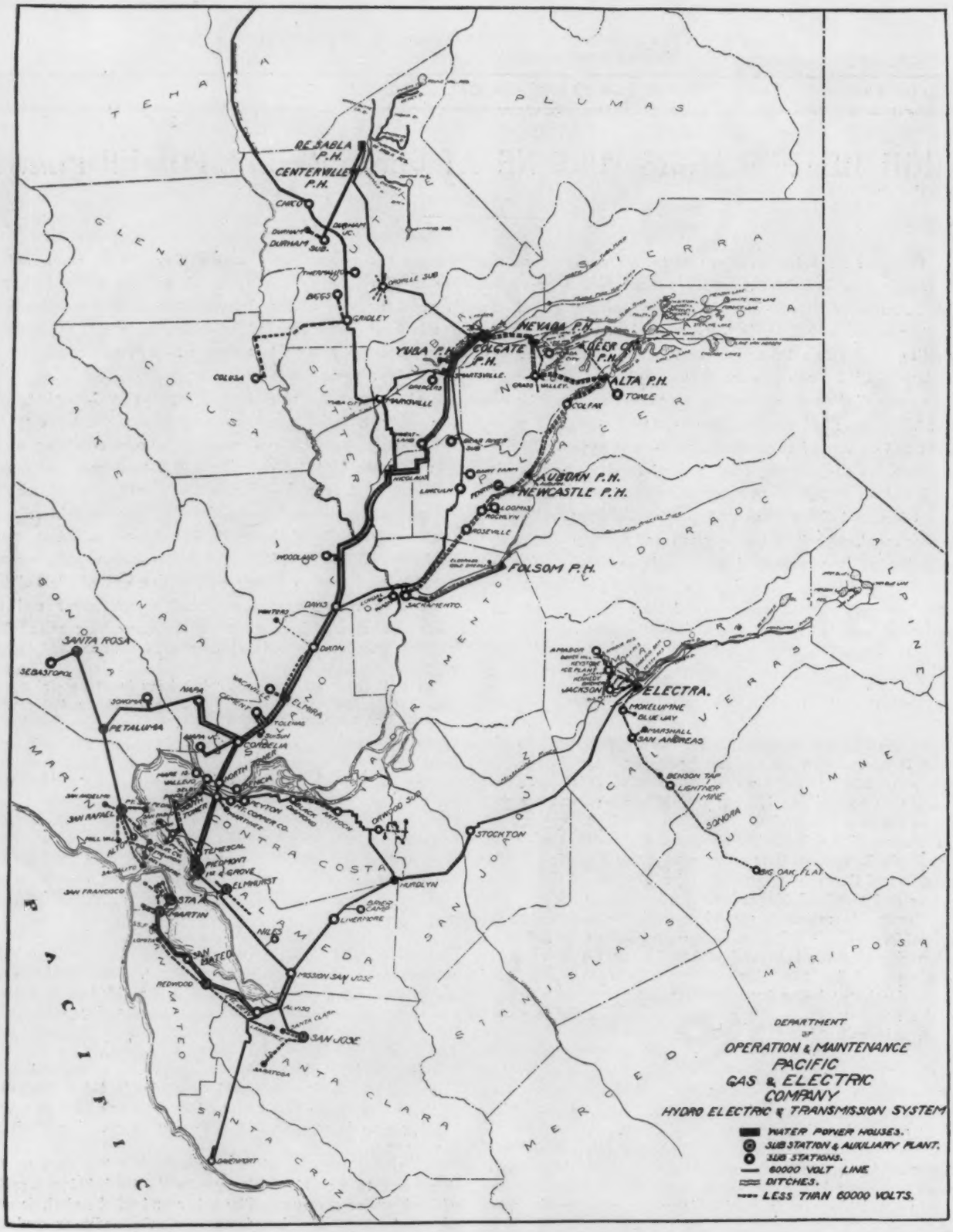
The Francis turbine, which has been in successful operation during the past three months, is of the radial inward flow, single axial discharge type, with horizontal shaft. It operates under a total head of 591 feet from the surface of head water to normal tail water. At full load, with 400 revolutions per minute, this is equivalent to an effective head of 565 feet. Owing to the limited capacity of the generator, 5,500 kilowatt, the wheel has never exceeded 8,200 horsepower, though the rating is 9,700 horsepower. The discharge is 155 feet per second, and the total weight 117,000 lbs. The guaranteed efficiency at full gate is 80 per cent, at three-quarter 82 per cent, and at one-half 77 per cent.

The spiral casing is of cast steel, made in two parts, provided with a quarter turn discharge to the draft tube, and equipped with a pressure regulator. The turbine shaft consists of one piece of forged steel provided with a swell for receiving the runner and with forged flanges forming half of the coupling for direct connection to the generator. The runner is of cast steel with twenty vanes.

Twenty-four pivoted guide vanes are connected to a cast steel speed ring, designed to gradually bring the speed of the water up to that acquired by the guide vanes. This shifting ring is connected to the governor rocker shaft by lever arms.

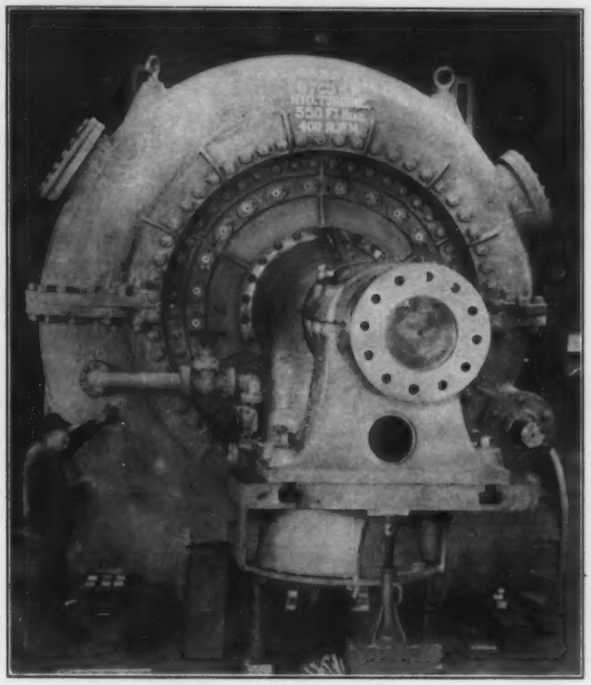
A thrust bearing of cantilever type takes up any end thrust caused by sudden changes in the load, being supplied with oil under pressure. The other end of the shaft is supported by a ring oiling bearing of the ordinary pedestal type on the discharge side of the wheel.

The discharge pipe is bolted to the riveted steel draft tube, which leads to the concrete lined tunnel, as shown in the general section.



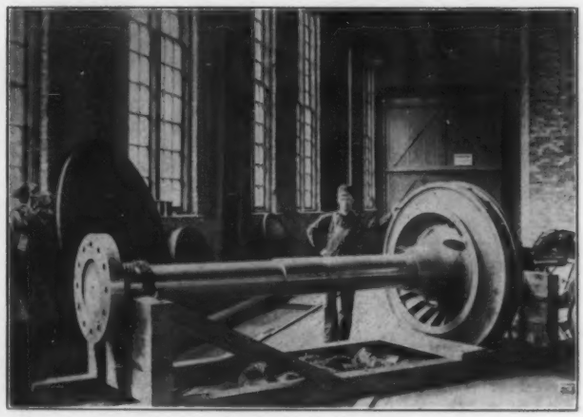
CALIFORNIA GAS AND ELECTRIC CORPORATION GENERATING AND DISTRIBUTING SYSTEMS.

This also shows the location of the pressure regulator, or relief valve, which is governor operated, and is designed to relieve the pipe line and wheel casing of excessive pressure and water hammer when the vanes are closed. If the



9700 H. P. FRANCIS TURBINE.

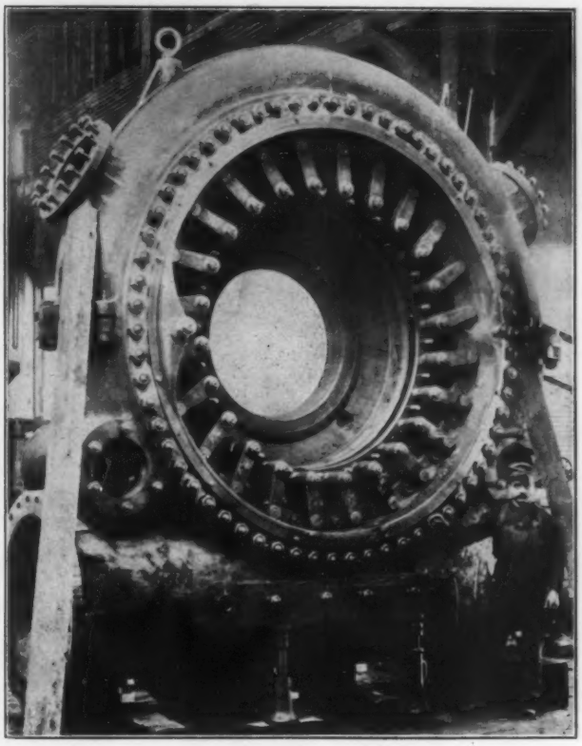
guide vanes are suddenly closed, the pressure regulator discharge is opened, but has a general tendency to close, doing so gradually through the agency of a relay valve and dashpot arrangement. If the vanes are closed slowly, the regu-



RUNNER FOR 9700 H. P. TURBINE.

lator does not operate. The dashpot can be cut out, and the pressure regulator will then act as a by-pass, being closed when the vanes are open, and vice versa. Tests were made of the relief valve at the time the turbine was first put in operation. The machine was running at full load, or discharging about 155 second feet, the vanes were suddenly closed, the relief valve opened at the same time, and closed after a period of 30 seconds. The total rise in pressure was 16 pounds above the static, or 28 pounds above the working pressure. With conditions at 1,000 kilowatt load, the time of closing was 5 seconds, and the rise in pressure above static was 41 pounds, or 42 pounds above the working pressure. The guide vanes and relief valve are operated by a Type N Lombard governor, which is connected to the rocker shaft by suitable pinions and a segment, the relief valve being lever connected to the bell crank of the shifting ring lever.

With this type of wheel it is necessary to have a load

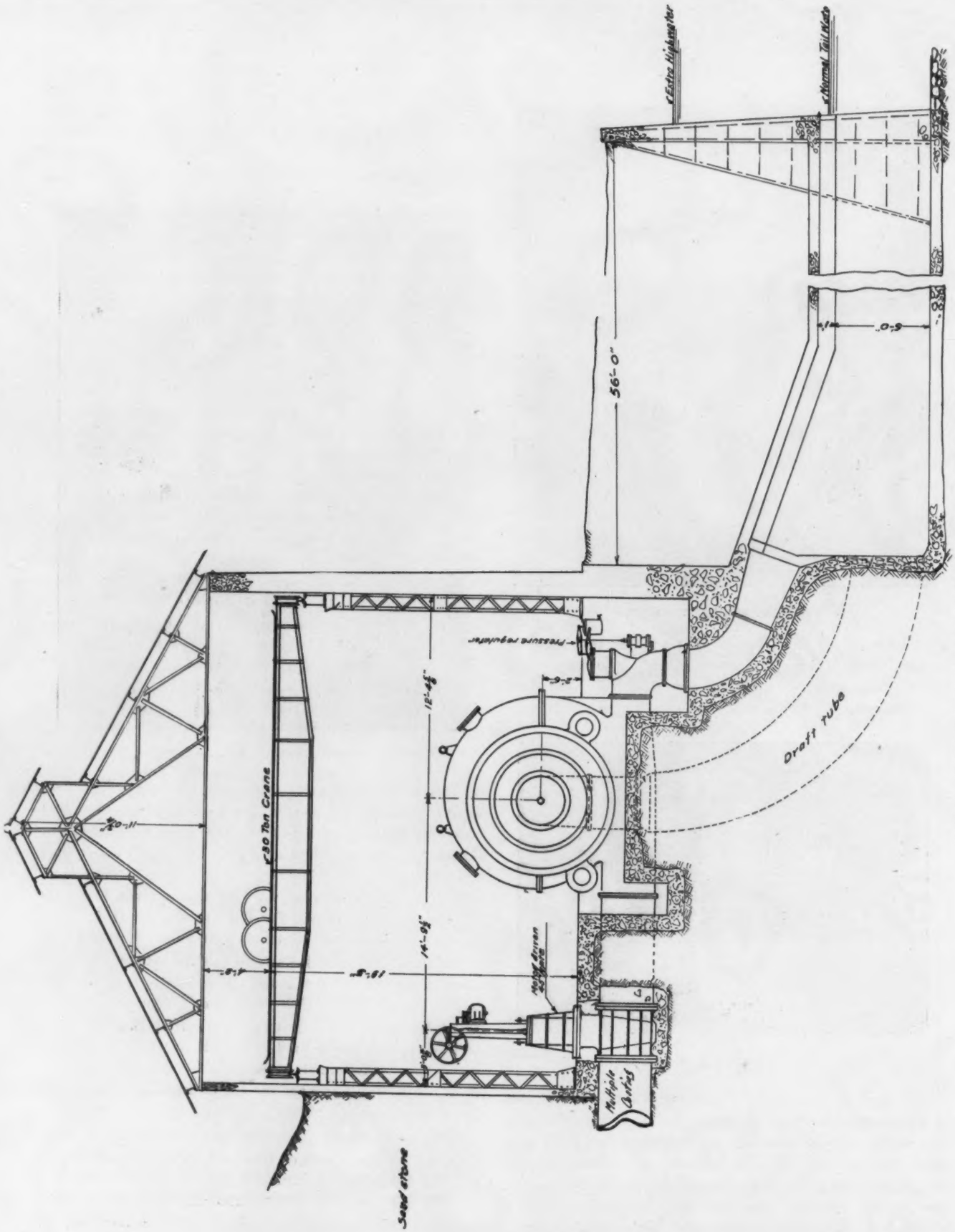


SHELL AND GUIDE VANES.

limiting device for regulating the gate opening. For if additional load comes on the system, the governor would ordinarily open the guide vanes, possibly to such an extent that more water would be used than the canal at that time may be furnishing. Or the generator may become overloaded, as the capacity of the turbine is greatly in excess of that of the generator. For this purpose, Mr. J. P. Jollyman, superintendent of electrical construction, devised a load limiting device of an adjustable connection between the valve-stem pinion and the rocker shaft of the anti-racing mechanism on the governor. This device works admirably and enables the operator to adjust the governor so that the wheel will not exceed any desired load. The machine is provided with current transformers included in the armature circuit so as to automatically trip turbine out of commission in case of line or machine short circuit.

The governor oil pump is of the triplex 4x6-inch type, furnished by the Lombard Governor Company, and is run by a 7.5 horsepower induction motor.

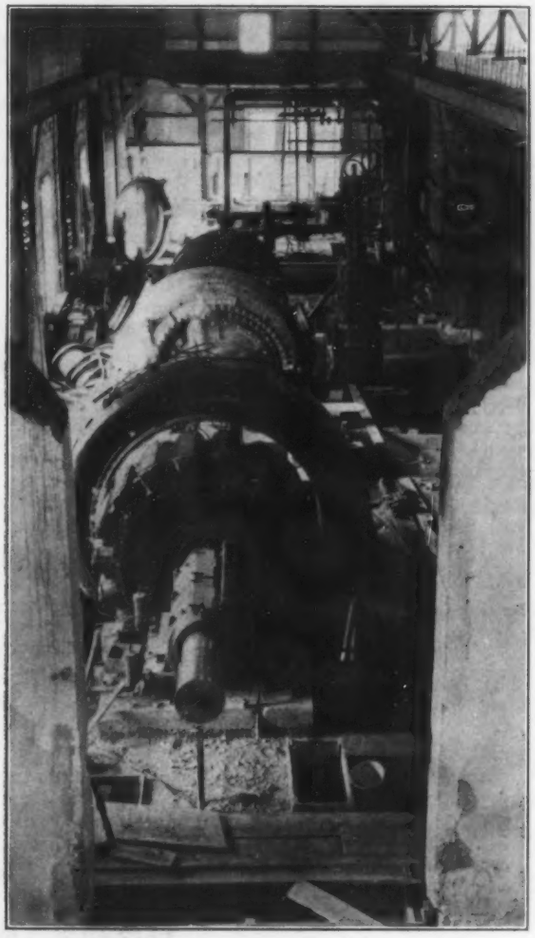
The generator is a 5,500-kilowatt, 3-phase, 60-cycle, 2,400-volt, 400 revolution per minute machine, furnished by the Stanley G. I. Electric Manufacturing Company. The revolving element is supported on a 16-inch shaft between two oil-



GENERAL SECTION OF FRANCIS TURBINE AT CENTERVILLE PLANT.

ing ring bearings. The generator and water wheel shafts are connected by a bolted flange coupling. Excitation is secured from a water wheel, motor exciter set of 60 kilowatt capacity.

Six 840-kilowatt, and three 360-kilowatt shell-type water-cooled transformers complete the main features of the installation. The circulating water for the transformers is used under a fifty-foot head, and is piped from a reinforced concrete tank, ten feet in diameter, and six feet deep, with four-inch walls. Clinton wire fabric was used for reinforcement, and the tank was absolutely water-tight without the use of any water proofing material.



INTERIOR OF CENTERVILLE POWER PLANT.

The high tension lines (60,000 volts) are led from the transformer room out of the end of the building to a reinforced concrete fireproof switch house provided with "Baum" high tension switches and open air switches, for cutting on or off the de Sabla lines. The switches are lever controlled from the switch board.

Mr. J. P. Jollyman, superintendent of electrical construction, under the direction of Mr. C. F. Adams, assistant electrical engineer, had charge of the electrical installation. Mr. Kramer, of the Allis-Chalmers Company, assembled the turbine, and the hydraulic and civil engineering work was carried on under the direction of James H. Wise.

The turbine was furnished by the Allis-Chalmers Company of Milwaukee, and was designed by Mr. Arnold Pfau, their engineer. It was through the efforts of Mr. F. G. Baum, formerly chief engineer of the California Gas and Electric Corporation, that this departure from the customary turbine practice was made.

In closing, the speaker showed the field to which the so-called high head turbine is best fitted.

For the past few years the general tendency has been on large systems to install electrical units of large capacity and high speed for the sake of economy in first cost, operation and maintenance. Impulse wheels are adapted to such installations with pressure heads of say 800 feet and upwards (with reference to units of 5,000 kilowatts and over, and not less than 300 revolutions per minute). But for low heads, or for medium heads, say in the neighborhood of 300 to 600 feet, the turbine is better fitted for large units, as can be shown by comparison, taking the installation just described.

The quantity of water used is approximately 155 second feet. If impulse wheels were used, there would be required two wheels with nozzles of about nine inches in diameter, or three wheels with about seven and one-quarter-inch nozzles, the latter would be allowable, but a speed of 400 revolutions per minute would be entirely out of the question, for with that speed, a pitch diameter of about 4 feet would be necessary (considering the speed of the pitch circle 46 per cent of the spouting velocity). That means that the disc would have a diameter of say 3 feet, the buckets on the other hand would have to be about 18 inches in width, and such a combination of large buckets on a small disc would be neither mechanical nor efficient.

With a 300 revolution per minute machine, the pitch circle would be a little over 5 feet, or a disc diameter of about 4 feet, but with the same size buckets, which is still an undesirable arrangement. We may arrive at the conclusion then, that at least three impulse wheels would be necessary, the speed being 250 revolutions per minute. We would, therefore, have three wheels instead of one, and a more expensive generator.

With the turbine, on the other hand, a single wheel only is necessary, the speed if desirable could be increased to about 500 revolutions per minute. Also generators of larger capacity than 5,500 kilowatts could be used.

Furthermore, we should not lose sight of the fact that by means of a draft tube, the turbine can gain additional head over that of the impulse wheel, for in the installation just cited, the impulse static head is 577 feet against the total head on the turbine of 591 feet, an increase of about 2.4 per cent, which means 2.4 per cent more power for the same quantity of water. The reader may arrive at his own conclusions.

It is proposed that the word "kelvin" be laid before the International Standardization Commission as the kilowatt-hour unit, thus honoring the memory of the late Lord Kelvin and giving a short expression for the cumbersome kilowatt-hour as the English Board of Trade unit.

COMPRESSED AIR CALCULATIONS.*

By E. A. Rix, Mem. Am. Soc. C. E., Mem. Am. Soc. M. E.

Fellow Students:

The great progress in the Arts and Sciences is made for commercial reasons and by people who are seeking either gain or a livelihood. The trade catalogue is one means by which advance information is given the public, and in it the data and tables and scientific information are mostly theoretical. It is not considered prudent by business men to take the public into their confidence and give them the practical co-efficients which have cost years, much money, and hard work to acquire. For this reason, catalogue information is ofttimes very misleading, and is valuable only as a means of comparison.

No matter what theoretical engineering course we take, to be valuable to the community, we must all take a post-graduate course of experience and become commercial engineers. The sooner we reach that degree, the better for ourselves and everybody concerned. Theoretically and actually, you may have a million dollar ore body, but if it costs more per ton to realize its value than it yields commercially, there is not a cent in that ore-body. That, after all, is the only fact we wish to know, and we want to know it beyond a peradventure.

It seems to me, therefore, that if I am honest in my desire to help you, I must loosen up and give you practical commercial co-efficients, show you how we safeguard our own interests, and at the same time satisfy those with whom we deal. And finally, it seems to be about the best way in which one can repay this University for the benefits which he has received from a four-years' training.

Before we undertake to solve a problem which I shall present for your consideration, I shall give you some of the practical data which I use to make these calculations.

During the last twenty years, I have kept a log of all the compressed air plants I have tested, and also the actual performances of a great number, covering almost every kind of compressor and compressed air motor or tool, and I have averaged all the indicator cards taken from the various compressors used in mining work and compared the indicated horsepower with the actual power required, comparing this with the displacement of the compressor cylinders, I have concluded that for a safe and sane power factor, we must allow 20 horsepower for every one hundred cubic feet of cylinder displacement, to compress air from atmospheric pressure to 90 or 95 lbs. receiver gauge pressure at sea level.

I have made my calculations on these pressures because they are the standard pressures now used for pneumatic work, and nearly every machine and motor is constructed for these pressures. Twenty horsepower means brake horsepower, i. e., the power delivered at the shaft of the prime mover.

If you consult tables in any engineering magazine or trade catalogue, on air compressors, you will note that the power claimed to do certain work is much less than the figure which I give you, and in explanation, it must be noted that these tables are theoretical, and do not take into account the mechanical efficiency of the compressor, nor losses due to volumetric efficiency of compressors.

These figures are, therefore misleading, and should be avoided except to use as comparisons between one machine and another.

It is most unfortunate that the public is not given the results of working tests upon plants of all descriptions running under ordinary conditions, as such information is much more valuable than the records of official tests, which are usually made under special conditions by experts at the most satisfactory load—a set of conditions not often realized.

You must have a safe margin in your calculations so that neither you nor those for whom you are installing a plant will be disappointed, and I, therefore, have given you 20 horsepower per one hundred cubic feet of cylinder displacement as a figure that will never get you into trouble, and at the same time, it is not too generous. It may also be noted that it would be just as well in small plants to make no distinction between single and two stage machines. By small plants, I mean up to 400 cubic feet capacity.

Second.—Remember that a compressed air cylinder will never give a quantity of air equal to the volume swept by the piston, for the reason that such things as clearance, leakage, temperature, piston speed, etc., reduce the theoretical quantity so that it is best to figure about 80 per cent volumetric efficiency for the average mining compressor. Many do not give 60 per cent and some 90 per cent.

Third.—In using compressed air at 90 lbs. pressure cold, it will take 24 cubic feet of free air per minute to give one horsepower in plain slide valve engines, and 15 cubic feet with good expansion valve gearing, and between these two limits will lie all the various types of engines. If the air be reheated, to about 300 degrees Fahrenheit, it will reduce the above quantities about one-third. In one hoisting engine which we installed, having compound Corliss cylinders, and where the air was heated to 400 degrees Fahrenheit before entering each cylinder, it required between 7 and 8 cubic feet only for one horsepower. Most mines, however, use cold air and prefer the power loss to the trouble and expense of the installation and maintenance of reheating apparatus.

Fourth.—The tables set forth in the trades catalogues for the air consumption of standard piston rock drills are fairly accurate and are generally in terms of the compressor cylinder displacement.

Fifth.—For operating ordinary station and sinking pumps of the direct acting type, which is the ordinary stock pump usually used in mining operations, it will be safe for you to calculate that one cubic foot of free air compressed to ninety pounds gauge pressure will do 135 foot gallons of pumping.

Sixth.—That ordinary mining hoists have a mechanical efficiency of about 75 per cent.

Seventh.—For the determination of pipe sizes, losses of pressure and terminal pressures for compressed air transmission, I use the Johnson formula, which is very satisfactory:

$$P_1^2 - P_2^2 = \frac{.0006 V^2 L}{A^5}$$

Wherein P_1 = absolute initial air pressure.
P_2 = " terminal air pressure.
V = free air equivalent passing through the pipe.
L = length of pipe in feet.
A = diameter in inches.

This formula is quite simple to solve.

With these facts at hand, we can now readily calculate the problem we shall consider as follows:

PROBLEM.

A mine having a water power distant 5000 feet wishes to generate compressed air and transmit it to the collar of the shaft for operating purposes. The work to be performed is as follows:

100 tons of ore and waste to be hoisted in 20 hours.

30 gallons of water per minute to be pumped either at a station or a sinking pump.

5—2¼ standard piston rock drills to be operated.

3 air hammer drills to be operated.

General Conditions:

Depth of shaft, 600 feet.
Weight of skip and rope, 1,000 lbs.
Weight of ore hoisted, 1 ton.
Initial air pressure, 95 lbs.
Final air pressure, 90 lbs.
Altitude, sea level.
Geared hoist and unbalanced hoisting.

Required:

Size of compressor.
Diameter of air pipe.

*Published by courtesy of Mining Association of the University of California, before which this paper was read February 19, 1908.

Brake horsepower.

Altitude factors.

Re-heating co-efficients.

Note.—In problems of this kind, we must reduce all of our requirements to cubic feet of free air because free air is the basis for all power calculations.

To determine the free air required for hoisting: If 100 tons of ore and waste are to be hoisted in 20 hours, the hoisting will be done at the rate of 5 tons per hour, and inasmuch as each load hoisted contains one ton, it follows that there will be a load hoisted every 12 minutes. Of course, we know that an absolute schedule of 12 minutes between hoists can scarcely ever be carried out, for the intervals may be shorter during one hour and longer during another, or stop altogether, but the only way to figure it is on a regular basis, and after that is determined, allowance one way or another can be made for any irregularity.

The load being 2,000 lbs. of material and 1,000 lbs. of rope and skip, makes a total of 3,000 lbs. which is to be hoisted 600 feet. 3,000 lbs. lifted 600 feet will require 1,800,000 foot pounds of work, or 54 horsepower, theoretical. Inasmuch as the hoist has a probable efficiency of 75 per cent, the 54 theoretical horsepower becomes 72 brake horsepower actually required.

Using cold air, it requires, as we have mentioned before, 24 cubic feet of free air per horsepower. Then $24 \times 72 = 1{,}728$ cubic feet of free air which the hoist will consume to make one lift. This, you will note, gives us direct results without taking into consideration the element of time or the dimensions of the hoist. If we made a hoist every 12 minutes, and it required 1,728 cubic feet to make a hoist, then the compressor must furnish 144 cubic feet of free air per minute continuously, and we must have storage capacity sufficient to accumulate the air between hoists. Right here is the vital point of hoisting economically with compressed air.

Let us assume in our problem that we hoist at the rate of 300 feet per minute, then it will take two minutes to make the lift, and the hoist will be lowering and idle during the next ten minutes. During this ten minutes, the compressor is delivering 144 cubic feet of free air per minute, or 1,440 cubic feet total, which must be stored.

If the hoist is none too large for the work, you will find that if the pressure in the receiver drops more than one atmosphere or from 90 lbs. to 75 lbs., that the hoist will not operate in a satisfactory manner. Then, in our problem, if we must draw 1,440 cubic feet from the receivers at a drop of one atmosphere in pressure, the receivers must have a cubic capacity of 1,440 cubic feet, and if the hoist is amply large so that it will still operate after the receiver pressure has dropped two atmospheres, or from 90 lbs. to 60 lbs., then the receiver capacity can be one-half of 1,440 or 720 cubic feet, but it is not wise to go below this pressure, because it will effect too materially the pressure required for operating the other machinery.

For a first class job, install receivers having a capacity equal to the storage required at one atmosphere pressure. Right here let me say that large receivers cost less in proportion to their storage capacity than small ones. For example: A carload consisting of four receivers 54 inches in diameter by 30 feet long, containing about 2,000 cubic feet, costs at the present time about $1,600, while the same storage in ordinary receivers 48 inches in diameter and 12 feet long, would cost about $2,200. It is better to invest more money in receivers and less in compressors because the smaller compressor takes less power at the peak, and most power bills are figured on a constant peak.

If you install a plant and the receiver capacity is too small, you can always determine the proper quantity of storage by running the compressor with the unloader cut out, and if the receivers blow off between hoists and the pressure drops more than 15 pounds during hoisting, add more receiver capacity until it will not blow off nor drop more than 15 pounds. If you arrive at the point where it does not blow off and the pressure does not fall to 15 pounds, then slow down the compressor until the desired drop is reached, and you will be operating your plant at the most economical point. Then cut in the unloader again and let it work when it will. An unloader only saves wear and tear on the compressor where you buy power at the peak load, as happens in most cases, but does not affect your power bill.

Let us go back now to our problem. We find, therefore, that 144 cubic feet per minute is required for hoisting. Now, while we have allowed four hours in twenty-four, or an hour and twenty minutes on each shift for hoisting and lowering men, timbers, supplies, etc., it is entirely probable that at least once every hour some one will be going up and down the shaft, and it would be practical, therefore, to say that the hoist would handle six loads per hour instead of five, and we must therefore add twenty per cent to the hoisting requirement, making, say, 175 cubic feet instead of 144.

To determine the amount of compressed air required for pumping: For pumping 30 gallons per minute 600 feet, requires 30×600 or 18,000 foot gallons of work. If one cubic foot of free air at 90 pounds gauge pressure will give 135 foot gallons of work, we shall require 133 cubic feet of free air for the pumping. This requirement is constant.

To determine the amount of compressed air required for drilling: Five 2¼-inch rock drills will require 50 feet of free air each, or 250 cubic feet, and three air-hammer drills will require 25 cubic feet each, or 75 cubic feet. To get these amounts, take about eighty per cent of the requirements as stated in rock-drill catalogues, which always give quantites in compressor-cylinder displacement which do not deliver on an average within twenty per cent of their displacement, excepting in large machines.

Our total requirements will therefore be:

Hoisting	175 cubic feet
Pumping	133 cubic feet
Drilling	325 cubic feet
Total	633 cubic feet

This 633 cubic feet does not take into consideration any ordinary pipe leakage in the hoisting works and below ground, and in conducting this air from a distance, inasmuch as our problem calls for a transmission of 5,000 feet, it would be well to allow a leakage of five per cent on the entire system. This would bring our requirement up to 665 cubic feet, and if we allow that our compressor will give a volumetric efficiency of at least eighty per cent, we must have a cylinder displacement of 830 cubic feet per minute.

You will remember that our power factor was 20 horsepower per 100 cubic feet; consequently we must have 166 horsepower delivered on our water-wheel shaft to drive this compressor.

Finally, we must determine the size of the pipe, allowing five pounds drop in pressure for friction loss. You will remember the formula

$$P_1^2 - P_2^2 = \frac{.0006\, V^2 L}{A^5}$$

P_1 the initial pressure absolute $= 95 + 14.7$, or 109.7, and its square is 12034.

P_2 the terminal pressure we have stated shall be 5 pounds less than the initial or 90 pounds, or 104.7 absolute and its square is 10962.

The difference between these two, or—

$$P_1^2 - P_2^2 = 1072.$$

Substituting this in our equation, and also the values for L and V, we have—

$$1072. = \frac{6 \times 5000 \times 633 \times 633}{10000 \times A^5}$$

Reducing, we have $1072 \times A^5 = 3 \times 633^2$, or

$A^5 = 1121$

$A = 4$-in. pipe.

We have now to figure the size of the compressor required. If you happen to have tables and catalogues at hand, it will be

an easy matter to look up a satisfactory compressor having a displacement of 830 cubic feet, but if such literature is not at hand, the size of the compressor may be determined as follows:

It almost goes without saying that you would select a two-stage compressor for anything over 400 cubic feet capacity. This two-stage compressor will have a low-pressure or gathering cylinder, wherein the air is compressed to about 25 pounds, and a high-pressure cylinder where the air at 25 pounds after it has been cooled will be compressed to 90 or 95 pounds pressure. The reason a two-stage machine is selected is because it has a higher volumetric efficiency, requires less power to operate it, is easier to lubricate on account of lower temperatures and has less strains on the mechanism.

The first thing to consider is the speed at which you will operate the compressor, and this will be dictated by many things. If you have a limited amount to expend, you will naturally select as high a working speed as possible, because the higher the speed, the smaller the compressor.

Again, you may have to take the future into consideration, and you may want more air later on, as the shaft goes deeper or more water is encountered. You would then naturally select such a speed as would give you the margin of additional power required.

You may take 150 revolutions per minute as the maximum for compressors from 400 to 1,500 feet capacity, and 100 revolutions per minute as a speed that will give you a fifty per cent margin for the future, so let us assume that the mine in question has a future, and take 100 revolutions per minute, If our requirement is 830 cubic feet per minute we shall then require an intake or compression cylinder which will give us 8.3 cubic feet per revolution, and inasmuch as the cylinder is double-acting—that is to say, makes two displacements per revolution, the cylinder must have a cubic capacity of 4.15 cubic feet.

Experience dictates that the average compressor cylinder is built for the following strokes and capacities:

6-in.	stroke	up to	50-ft.	capacity
8-in.	"	"	100-ft.	"
10-in.	"	"	200-ft.	"
12-in.	"	"	500-ft.	"
16-in.	"	"	700-ft.	"
18-in.	"	"	1500-ft.	"
24-in.	"	"	2500-ft.	"

Our compressor will therefore be best suited by an 18-inch stroke, or 1.5 feet. If the capacity is 4.15 cubic feet and the stroke 1.5 feet, the area of the cylinder will be $\frac{4.15}{1.5}$=2.75 sq. ft. or 397 square inches, which is the area of a 22½-inch cylinder. The low-pressure cylinder will therefore be 22½×18.

It is very evident that if we have two cylinders to do our compressing, that there is no good reason why one cylinder should do more work than the other, and there is a very good reason why the work performed by these cylinders should be equal, viz.: because the total work and temperature developed will be at a minimum, just why—would lead us into mathematics, and so you must take the statement as a fact.

There is also the mechanical reason that the strains on the machine will be at a minimum, and if you construct the compressor of the duplex type, both sides will be alike, except as to the cylinders. It can be easily shown by algebraic method that if our two cylinders perform equal work, the intermediate pressure must be a mean proportional between the initial absolute pressure and the final absolute pressure, and the cylinder ratios will be as the ratios of either the high or initial absolute pressure to the intermediate. In other words, to put this in such shape that you will easily remember it,

If P =absolute initial pressure
P_1 =absolute intermediate pressure
P_{11}=absolute final pressure
then $P_1=\sqrt{P\times P_{11}}$

Take our example: Our initial pressure is atmospheric or 147 absolute. Our final pressure is 95 pounds gauge or 109.7 absolute. The intermediate pressure will then be $P_1=\sqrt{14.7\times 109.7}$ or 40 pounds absolute=25.3 lbs gauge pressure. Our proportion then stands 14.7:40::40:109.7, which represents a ratio of

$$\frac{40}{14.7} \text{ or } \frac{109.7}{14.7} \quad 2.74$$

The cylinder ratios will therefore be identical with the pressure ratios and our high-pressure cylinder will have a capacity of $\frac{1}{2.74}$ of the low pressure. The strokes being the same, the area of the high pressure cylinder will be $\frac{1}{2.74}$ of the low pressnre, which was 397 square inches. Dividing this by 2.74, we have 145 square inches as the area of the high-pressure cylinder. This corresponds to a diameter of 13½ inches. The compressor will then be a 22½-inchx13½-inchx18-inch stroke, and you will be justified in taking the nearest size to this that the manufacturers can supply.

You will note that as the altitude increases, the initial absolute pressure diminishes, and as the final pressure remains the same, the pressure ratio grows larger as the altitude increases. For example: At 10,000 feet the atmospheric pressure is 10 pounds instead of 14.7 pounds, and if you go through the same calculations that we have just made, you will find that the cylinder ratios will be 3.3 instead of 2.74, and this will make the high-pressure cylinder only 12½ inches in diameter instead of 13½ inches in diameter, and the intermediate pressure will be 18.3 pounds instead of 25.3 pounds. Such a compressor would not, however, be able to do the work contemplated in the problem we have considered, for the reason that while the weight of air necessary to do work remains practically the same for reasonable altitudes, the capacity of the compressor diminishes as the altitude increases. It is true the volume remains the same, but it has not the weight and therefore you must increase the size of the cylinder required at sea level by the ratio between the ratio of compression at sea level and the ratio of compression at altitude.

In our problem, the ratio of compression at sea level is 7.5 and the ratio of compression at altitude of 10,000 feet is 11. The sea-level compressor must be increased therefor, $\frac{11}{7.5}$ or 1.47 times, to give the same weight of compressed air at 10,000 feet altitude, or, to put it even more simply, it will take 11 strokes of the same-sized compressor piston at 10,000 feet altitude to give the same compressed air or to do the same work as 7½ strokes will do at sea level.

In our problem this would make a low-pressure cylinder of 27 inches instead of 22½ inches, and a high-pressure cylinder of 15 inches instead of 13½ inches. In other words, this altitude compressor is nearly fifty per cent larger to do the same work.

A proper understanding of these simple calculations will enable you to check up compressor sizes and proportions, and no one could furnish you with a sea-level compressor for an altitude one, and *vice versa*. We have assumed eighty per cent volumetric efficiency in this problem, but if the compressor happens to be a slow-speed, mechanical-valve machine, ninety per cent could be assumed. The figures I have given you are safe, and taken from average plants, and it will be necessary for you to use your judgment in assuming a higher or lower factor.

To determine the amount of compressed air required for re-heating: It is practical to re-heat air from 300 to 400 degrees Fahrenheit in various ways and great economy realized, especially for pumping and hoisting, and if it is possible you may reduce the quantities of cold air which we have figured for this work by the ratio of the atmosphere to the compressed air temperature absolute. Thus, if the atmosphere is at 60 degrees Fahrenheit or 520 degrees absolute, and the compressed air is used at 300 degrees Fahrenheit or 760 degrees absolute, then the cold air volume for your work may be taken at the

ratio of $\frac{520}{760}$, or about seventy per cent, thus making a saving of thirty per cent.

In conclusion, let me caution you about being led astray by that Will-o'-the-Wisp "Efficiency" when you come to choose between compressed air and some other power to do mining work. "Utility" should always be the standard for comparison.

It is seldom that any set of conditions call for the exclusive use of one kind of power, and it is not good engineering to make an installation the victim of any fad or prejudice. Whether it be steam, electricity, water power or compressed air, or a combination of any or all of them, let the sole and only qualification be determined on the basis of commercial efficiency.

ELECTRIFICATION OF RAILWAYS.*

By Dr. Gisbert Kapp.

(Continued.)

Classification of Electric Railways.

We may classify electric railways either by the kind of current supplied to the train or by the kind of motors used. It is obvious that the two classifications need not necessarily be identical. We might, for instance, supply single-phase current to the train, and by using converting apparatus on the train use three-phase motors or continuous-current motors. Taking, however, the motors as the basis of classification, we have in chronological order: (1) the continuous-current system; (2) the three-phase system; (3) the single-phase system. In the oldest system, which at present also has the greatest mileage, the motors are of the series type, and are worked on what is known as the series-parallel control. That is to say, by means of a special multiple-contact switch the motors are put in series at the start, and as the train gathers speed their connection is gradually changed to parallel, the finer subdivisions of speed being obtained by variable resistance in the armature circuit and by varying the magnetic flux in the field system. A further development is the so-called "multiple-control system," which, although first used with continuous-current motors, has also been adapted to the other motors. Both the series-parallel and the multiple control are the invention of Mr. Sprague, and have been adopted in one form or another by all makers of electrical equipment. The leading idea is this: Each motor coach is provided with its own equipment of switches, called "contractor," which regulate the supply of current to the motors of that coach alone. Any desired number of such motor coaches can be made up into a train with or without the insertion of "trailers"—that is, coaches not equipped with motors. All the coaches are joined by a multiple cable which carries the relay currents for working the contactors. The ends of this control cable, also called the "train line," are connected from coach to coach by coupling sockets, much in the same way as the brake pipes in our railway trains are connected. In each motor coach there is a master controller by which the relay currents for working the contactors are regulated, and it is thus possible to work the whole train from any motor coach. Each motor coach forms an independent unit, taking current from the third rail or overhead trolley wire as if it were running alone, but, by reason of the electric control, it takes the current exactly in the same way as any other motor coach in the same train, so that all the motor coaches take an equal share in propulsion. In this manner a large part of the total weight of the train is adhesive weight, and it is quite easy to get an acceleration as high as three feet per second per second. The high acceleration is of great advantage in the tube railways and other urban lines where, on account of the small distance between stations, a rapid start is essential for quick travel. The multiple-control system has also the advantage that the efficiency of control is quite independent of the length of the train, that trains can be made up without any need to observe a special grouping of coaches, and that in the event of one motor equipment failing it can be cut out of circuit, and its coach will then simply become a trailer, the other motor coaches working as usual. To reduce the stress on drawbars, it is customary to make the first and last coach motor coaches, but this is not essential to the system.

The General Electric Company of America have arranged an equipment of a motor coach for multiple control for a line where part of the way continuous current is supplied whilst the remainder receives single-phase alternating current. Such a condition of supply may arise where the main-line system joining two towns has to be interlinked with urban systems at either end. If the urban lines are worked by continuous current, the main-line train must be fitted to take this also, whilst for the main line proper high-tension alternating current is the only commercially possible method of power supply. The single-phase commutator motor can also be worked with continuous current, and part of the equipment, such as resistances and contactors, can be used for both. There are only some minor alterations necessary when passing from one kind of supply to the other, and these are made by the turning of a switch handle. There is a master controller at each end of the coach. The propulsion is effected by four motors, which at starting are all put in series connection. When half speed has been reached the connections are altered to two in series and two parallel, and when nearing full speed all the four motors are put in parallel. Since the motors are series wound the speed adjusts itself within wide limits to the load—that is to say, with the controller in the same position the speed will be much higher on the level than on an up grade. The same is the case with commutator single-phase motors. Also with such an equipment the motors run slower up hill than on the level, and the demand for power does not vary within quite so wide limits as would be the case were the run made with constant speed irrespective of gradients.

Such a condition of working is, however, not only possible with three-phase motors, but it is their normal condition, and if we wish to get away from it we must apply special means. The speed of a three-phase motor is only very slightly influenced by the load. When running loaded the speed may drop some three or four per cent, and this is so small a variation that we can say the speed is independent of the load. It depends only on the construction of the motor (number of poles, gear ratio, and diameter of wheels), and on the frequency of the supply current. This, of course, is constant. At starting, resistance is inserted into the secondary circuit and gradually withdrawn as the motor speeds up, but once all the resistance is withdrawn, and the motor runs at the full speed corresponding to the frequency, it will keep that speed whatever the gradient of the line may be. There is no possibility of running faster to make up lost time, but there is also no possibility of racing downhill; the train runs its even pace.

(To be continued.)

*Lecture delivered before the Royal Institution of Great Britain.

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EDITORIAL.

THE FRANCIS TURBINE.

The world's largest and highest head water turbine has been in successful operation for the past four months at the Centerville plant of the California Gas & Electric Corporation. This is a Francis single wheel, rated at 9,700 horsepower at an effective head of 565 feet, direct connected with a 5,500-kilowatt generator. It occupies the space formerly required for two 400-kilowatt impulse wheels, and is operated in parallel with the ten other hydro-electric plants of this corporation, making a second use of the water that has already developed 14,000 kilowatts at the De Sabla plant under a head of 1,530 feet. As the entire system is controlled largely from the plant at Electra, this installation does not require accurate regulation. Our readers will find much of interest in the paper we summarized this week, as read by Mr. James H. Wise, before the local Association of American Civil Engineers. Much credit is due to Mr. F. G. Baum, who advocated this type for such a high head, and also to Mr. Arnold Pfau, of the Allis-Chalmers Co., who designed it.

It is a noteworthy coincidence that Francis brought out this new turbine design in 1849, the same year that Californian streams became the Mecca of gold-seekers throughout the world. During the fifty-nine years that have since elapsed, this turbine has been changed by American manufacturers so as to be more valuable, just as the Sierran streams have become more valuable for their power than for their gold. Today, for medium heads, the turbine threatens to displace the modern successor of the hurdy-gurdy which was first developed in the attempt to harness these very waters.

The wheel is mounted on a horizontal shaft, and has a radial inward flow, and single axial discharge. The characteristic feature of such a reaction turbine is that the wheel-passages are completely filled by the water flowing through them, the pressure varying continuously between the point of admission and discharge. With a submerged turbine, the effective head is increased and the kinetic energy of the discharged water reduced by means of a draft tube or diverging passage. Such a diffuser gradually reduces the velocity of the stream before it passes into the tail water.

This wheel consists essentially of an outside ring supporting stationary curved guide-vanes and an inside runner, on which are mounted moving reversed-curve vanes or buckets. These latter receive the water simultaneously all around the periphery, being completely filled with water flowing under pressure. At the time of entrance it has had a certain direction imparted to it by the guide-vanes. This direction is gradually opposed, and its velocity restricted by the runner-vanes, which are thus caused to revolve.

From the pen-stock the water passes at the bottom of the turbine into the spiral wheel-case, in which it is progressively narrowed in its circuit around the guide-ring. After passing through the runner-vane it is axially discharged from one side of the wheel through a quarter turn pipe into the draft tube. There are two sets of guide-vanes, an outer set of four, and an inner set of twenty-four. These last are pivoted and mounted on a speed ring, which is lever-connected with the governor, by means of which they are opened or closed so that the amount of water admitted is varied with the load. They are close together at low heads, and as the load increases diverge to allow the passage of more water.

The fact that this reaction turbine displaced two impulse units brings up the mooted question of the relative advantages of these two types of machines, the former utilizing both the velocity and pressure of the water, the latter its velocity only. The answer to this question depends upon certain conditions as to head, loads, pipe size, velocity, etc., and also depends upon the designer's ability in interpreting and meeting these conditions.

Only four Francis installations are available on the Pacific Coast with which to institute a comparison with the hundreds of impulse wheels in successful operation. At Snoqualmie Falls the Seattle & Tacoma Power Co. is operating a 10,000-horsepower turbine under a head of 260 feet at a speed of 300 revolutions per minute; in the plant of the Truckee River General Electric Co. is a 3,000-horsepower wheel under 126-feet head; on Bishop Creek, California, is a 2,000-horsepower Francis turbine operat-

ing under a static head of 408 feet, and at Centerville is the 9,700-horsepower unit under a head of 565 feet. The first two have been in operation a little over two years, but the last two mentioned have been running but a few months.

From this limited experience it is evident that with regards to efficiency they are evenly matched, giving about 80 per cent. In the matter of price the turbine wheel is relatively cheaper, say, 12 per cent, and to this must be added the smaller space occupied and the additional tail-water head now utilized by the reaction wheel. In the matter of regulating and governing, the impulse wheel has much the advantage, though as already shown in the special case under discussion, local regulation is here unnecessary.

The problem of regulating the quantity of water supplied to a turbine without causing great loss in efficiency, is one that has been sadly neglected by the designers, whose habit of ordering a governor to furnish a certain number of foot pounds to operate the gate, is not much more successful than would be his ordering a pair of trousers for a man six feet tall and weighing 190 pounds, without having his measure taken by a tailor. This is in contrast to the European practice of designing the governor as an integral part of the installation.

Likewise, in the matter of varying loads, the impulse wheel gives higher efficiency over a wider range, and in inexperienced hands there is also less wear and tear of the impulse wheel. When such does occur it is more easily and quickly repaired than in the turbine. One broken turbine blade ordinarily causes more vibration and damage than a broken impulse bucket. This matter of wear is obviated by proper attention to the water supply, removing silt in settling basins and keeping out twigs by screens and grizzlies.

The relative merits of these two types we are not at this time prepared to discuss. With us the turbine is on trial, and, for medium heads of from 200 to 600 feet, and for large, steady output, requiring little regulation, it is giving eminent satisfaction. It is no more likely to invade the impulse wheel's proper province for heads as high as 2,000 feet than is the latter to be utilized for heads of twenty feet or less. The present difficulty of the control of the machine and of the relief valve will soon be overcome, and we will then have available another necessary factor in solving the integration of efficient hydro-electric power. Neither is a universal panacea—each has its limitations, but is necessary in its proper place. That of the turbine is large output under medium head.

The value of porcelain produced for electrical purposes increased in value from $2,253,061 in 1905 to $2,838,284 in 1906, a gain of 25.97 per cent. This product was reported from nine States in 1906 and composed 9.03 per cent of the pottery total, Trenton, New Jersey, being first, and East Liverpool, Ohio, second.

PERSONAL.

Clem A. Copeland has returned to Los Angeles from San Francisco.

F. C. Finkle is to have charge of the construction of the Edison Electric Company's new Kern River power plant.

A. E. Drendell, of the Drendell Electric Co., of San Francisco, has been in Los Angeles and San Diego during the past week.

Mr. Alexander Henderson, of the American Circular Loom Co., on his return from Honolulu, requested the "Journal" to thank the local electrical fraternity for the many courtesies rendered him and to express his appreciation of their hospitality and good-fellowship. This was inadvertently omitted in our last number.

F. E. Stewart has been appointed San Francisco manager for B. F. Kierulff, Jr., & Co., of Los Angeles, engineers and dealers in electrical equipment and Pacific Coast Agents for Chicago Insulated Wire & Mfg. Co., Waclark Wire Co., Heany Fireproof Wire Co., Hartman Circuit Breaker Co., Lord Electric Co., Sterling Electric Co., American Diesel Engine Co., Franklin Rolling Mill and Foundry Co., and Ideal Electric and Mfg. Co. The local office and warehouse are at 824 Folsom Street.

TRADE CATALOGUES.

Bulletin No. 150A, supplement from the Holtzer-Cabot Electric Co., shows new pattern "O" annunciator for house and elevator use.

H. W. Johns-Manville Co. send an interesting leaflet on asbestos, roll fire-felt, a pliable, indestructible material that is fire-proof, and forms an excellent insulator.

Type "K," direct current motors, are described in Allis-Chalmers Company's Bulletin No. 1057, which also contains illustrations of motor-driven machine tools.

Lighting transformers are described in Allis-Chalmers Company's Bulletin No. 1061, which not only contains a minute description of the transformers, but also information on insulating oil and insulation tests.

The Weston Electrical Instrument Co., of Newark, N. J., send a descriptive folder of the new Weston portable alternating current voltmeters, ammeters and mil-ammeters. These constitute a new group of portable Weston instruments for alternating current measurement. It is claimed that they have no chamber, inductance or working error.

Allis-Chalmers Co.'s Bulletin No. 1512, entitled "Compound Reynolds-Corliss Engines," contains information on the building of compound engines, from the first one known as the famous "Centennial" engine, to those recognized today as embodying in their design and construction the very highest development of the engine builder's art.

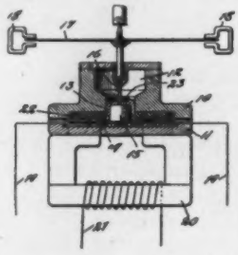
WARNING.

An individual calling himself "Capt. Pearson," of London, has been victimizing engineers throughout the country by a tale of alleged hard luck. He represents himself as an artillery officer and has various stories. The following description of him has been furnished us: Height 5 ft. 9 to 10 in.; weight 140 to 150 pounds; eyes, black or dark brown, shifting nervous; mustache black, small; not well dressed, slovenly; build, spare, light; complexion bloodless, pale, looks rather consumptive; teeth, bad, hair black; age about 40 years. This person has left Philadelphia, and may be expected to turn up in any of the large cities of the United States.

PATENTS

ELECTRIC MERCURY-MOTOR METER. 878,629. Jacob H. Hodde, Springfield, Ill., assignor to Sangamo Electric Company, Springfield, Ill.

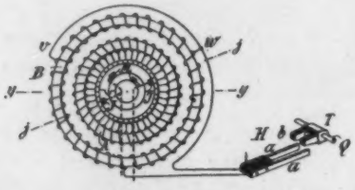
The combination with a body of mercury and a spindle



rotating therein, of a washer of non-amalgamable material loosely surrounding spindle at the point where it enters the body of the mercury, washer being provided with an amalgamated under surface.

SINGLE-PHASE MOTOR. 878,923. James J. Wood, Fort Wayne, Ind.

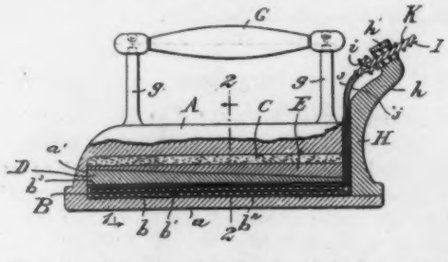
In a single-phase motor, a rotor winding provided with both commutator and collector rings, two sets of brushes adapted to engage said commutator and collector rings respectively, connections from both sets of brushes to an ex-



ternal source of current, means mechanically connected to said brushes for bringing them alternatively into engagement with said commutator and collector rings respectively, and a stator winding short-circuited on itself on a definite line.

ELECTRICALLY-HEATED SAD-IRON. 879,046. Harry Hertzberg and Maurice J. Wohl, New York, N. Y.

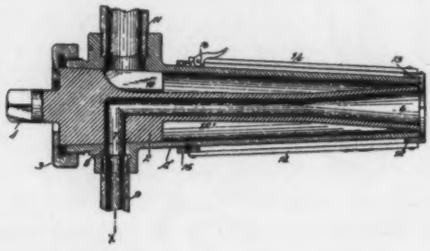
In a device of the class described, a chambered body or mass of metal, an electrical heater therein, and upper and



lower wedges for clamping said heater into close contact with said body or mass of metal, certain of said wedges being spaced and providing air circulation spaces through the chamber of said body or mass.

OIL-BURNER. 878,874. Clark S. Evans, Oakland, Cal.

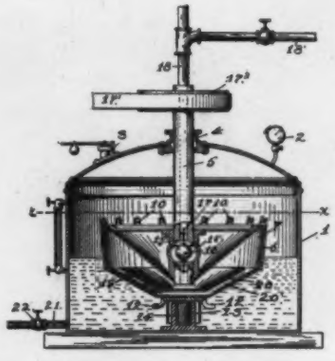
In an oil burner, the combination of a shell open at both ends, shell having a conical bore, a single plug seating in and turnable in the bore, plug having separate oil and



steam ports registerable with corresponding ports in the casing, plug having a longitudinally extending steam passage and shell having a longitudinally extending oil passage concentric with steam passage, plug being turnable to regulate the admission of both the steam and oil.

AIR-COMPRESSOR. 878,579. Lamartine C. Trent, San Francisco, Cal.

An apparatus comprising a pressure tank or cylinder, a receiver rotatably mounted therein, an inlet in receiver for the admission of water, an air supply for admitting air to the in-



terior of the receiver at the point of the admission of the water, outlets in the receiver for the escape of air under pressure, an auxiliary water inlet for receiver connecting with the interior of tank or cylinder and means for imparting rotation to the receiver for centrifugally forcing air and water therefrom under pressure into the pressure tank or cylinder.

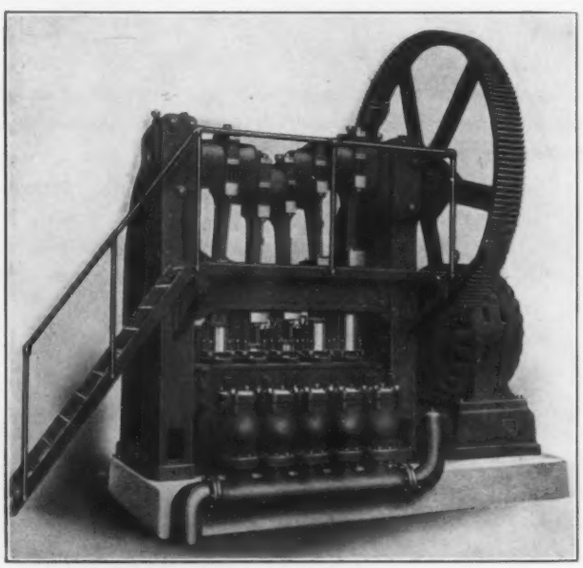
ATTACHMENT-PLUG. 879,723. Reuben B. Benjamin, Chicago, Ill., assignor to Benjamin Electric Manufacturing Company, Chicago, Ill.

An attachment plug for electric lamp sockets comprising an insulating base, a movable lamp contact carried by said base, a ring having a slot formed therein associated with said base, said slot being adapted to engage said lamp contact, said ring being adapted to remove said contact from engagement with lamp socket to permit the plug to be inserted therein without rotating the plug.

INDUSTRIAL

ELECTRIC PUMPING INSTALLATION IN THE ANACONDA COPPER MINES.

An interesting electric pumping installation is being made by the Anaconda Copper Company in its mines at Anaconda, Montana. The pump, which is illustrated herewith, is a 6x12 Aldrich Vertical Quintuplex type made by the Allentown Rolling Mills, Allentown, Pa., and is designed to deliver 425 gallons of water per minute against a head of 1,100 feet. This pump is to be driven by a Westinghouse type "CCL" alternating-current motor of 150-horsepower capacity at 450 revolutions per minute.



MOTOR DRIVEN PUMP.

The duty calls for heavy, substantial construction, and acid-resisting material was required to be used in making the throat and plungers and other parts of the water end, on account of the bad condition of the mine water which is to be handled. The use of five plungers operating from one crank shaft, having connecting rods placed 72 degrees apart, gives a uniform velocity of water in the pipes, thus adding greatly to the efficiency of the outfit.

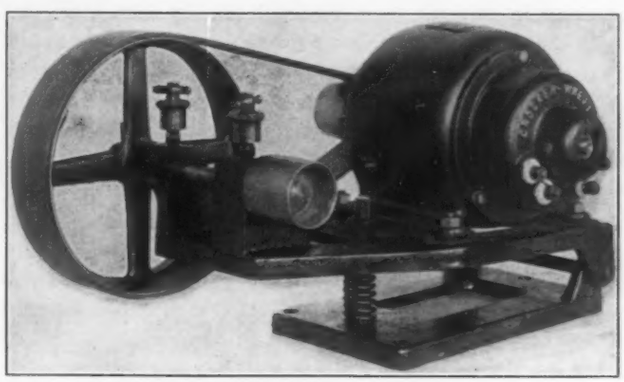
The plungers are single acting and outside packed. It is claimed that, owing to the large size of the throats and valves and the comparatively low water velocity through all the orifices, a high efficiency is obtained. This type of pump is becoming very popular in the Montana copper country by reason of its reliability and high efficiency, both of which are particularly important in mining operations, especially where power is purchased from transmission lines.

COUNTERSHAFT BELT TIGHTENER.

An ingenious and simple device for tightening the driving belt of an electric motor has just been perfected by the Crocker-Wheeler Company and is shown in the accompanying illustration. It consists of a countershaft and a simple and effectual belt tightener. Though designed for the peculiar requirements of linotype machines, it can be used to advantage with any machinery requiring slow speed drive.

The device consists of a cast-iron base, on which are mounted the motor and countershaft. The base is pivoted at one end to a sub-base, and belt tension is produced by means of an adjustable nut at the other end. A spring is provided to support the movable base in case of breaking of the belt. The belt between motor and countershaft is tightened in the usual way, by shifting the motor on the movable base with the aid of an adjusting screw.

It will be readily seen that this device is much more effective than a simple idler. Not only does it keep tension



CROCKER-WHEELER MOTOR.

on the belt, but by the use of the countershaft a great difference between sizes of driving and driven pulleys is avoided, and the belt therefore makes contact with a greater arc of the driving pulley, with consequent absence of slip.

The motor is of the Crocker-Wheeler "L" type, made in sizes from 1-20 to 5 horsepower. Of neat appearance and compact design, it is specially suited for application to small tools, printing presses, pumps, and all kinds of light machinery. Thousands of applications have been made with the Form L motor, which has become a standard machine. By means of simple covers for the openings in the frame, the motor is easily rendered dust and moisture proof, in cases where an open type of motor would be out of the question.

The Haller Sign Works, of Chicago, Ill., write that they will sell the right to manufacture and sell electric signs and letters under their patents in the territory west of the Rocky Mountains.

DEARBORN DRUG AND CHEMICAL WORKS.

Robert F. Carr and several of his associates in the Dearborn Drug & Chemical Works, have purchased the holdings of the estate of the late Wm. H. Edgar, who died two years ago, and at a meeting of the stockholders, followed by a meeting of the directors of the company, the following officers were elected:

Robert F. Carr, president and general manager; George R. Carr, vice-president; Grant W. Spear, vice-president; Wm. B. McVicker, vice-president and Eastern manager; J. D. Purcell, assistant general manager; W. A. Converse, assistant secretary and chemical director; R. R. Browning, assistant treasurer; A. E. Carpenter, superintendent. Mr. C. M. Eddy's holdings were also taken over, he desiring to devote all of his time to his personal business interests.

Robert F. Carr became connected with the Dearborn Company very soon after it was organized, entering the business shortly following his graduation, in chemistry, from the University of Illinois, in '93; for the past ten years he has been vice-president and general manager of the company, and during most of that time, especially the last few years, has been actively in charge of the business and organization.

Mr. George R. Carr has been connected with the company since he graduated from the University of Illinois, in chemistry, in '01. Mr. G. W. Spear, who is a graduate in mechanical engineering, University of Illinois, entered the business in '95. Mr. Wm. B. McVicker has been connected with the company for thirteen years, having during most of that time been at the head of the Eastern department. Mr. W. A. Converse, who was elected to the position of assistant secretary, has been in charge of the laboratories for the past twelve years. J. D. Purcell, the new assistant general manager, has represented the company in the railroad department for five years, having been with the company since 1896. Mr. A. E. Carpenter, superintendent, has had charge of the manufacturing department for many years, and is the oldest employee in the service of the Dearborn Company.

The preparations manufactured by the Dearborn Company for the treatment of boiler waters, both in stationary and railroad service, are most generally used. The scientific methods originated by their laboratories, of treating each water individually, as per requirements, after analysis, has made it possible for Dearborn preparations to give the highest efficiency with all classes of boiler feed supplies.

Catenary trolley suspension on the Syracuse Lake Shore & Northern Railroad is used for direct current operation of cars. This equipment was designed for single phase alternating current at 6,600 volts, but as only 4½ miles have been completed, and as all existing rolling stock is of direct current type, this system is being thus used temporarily. With concrete-supported steel bridges, 300 feet apart, and catenary construction, the cost was $800 per mile more than the standard suspension, with double sets of 35 feet wooden poles, 85 feet apart. The former is much more durable, gives clearer view of right-of-way, and is cheaper in operation.

JAPANESE HYDRO-ELECTRIC PLANT.

The General Electric Company is furnishing complete electrical equipment for a hydro-electric plant in Nagoya, Japan, a city with a population of about 250,000, situated some 300 miles from Yokohama. The main generating station will be built at Yawozo on the Naiko River, where power will be generated at 6,600 volts by four three-phase, 2,500 kilowatt, 60-cycle, 360 revolutions per minute water wheel driven generators. The generator voltage will be stepped up to the line voltage of 60,000 volts by twelve water cooled transformers of 1,000 kilowatt capacity each, and transmitted thirty miles to the main sub-station just outside of the city of Nagoya. Here, the line voltage is to be stepped down to 11,000 volts by nine water cooled transformers of 1,350 kilowatt capacity each, and transmitted underground to the distributing station through triple conductor lead armored cables, the city ordinances prohibiting an overhead transmission of over 3,500 volts.

In the central distributing station the voltage will be stepped down to 3,400 volts by nine water cooled transformers of 1,350 kilowatt capacity each, at which potential it is to be distributed throughout the city by both overhead and underground cables.

It is interesting to note that from the nearest railway station the entire power apparatus for the Yawozo station will have to be transported on specially constructed wagons drawn by oxen.

The Naiko River is normally 40 feet in depth, but in the rainy season the river often rises to 40 and 70 feet above low water mark. This rising characteristic of the river will necessitate the building of a specially designed dam to take care of the high water.

GENERAL ELECTRIC LAMPS.

In order to provide for the very heavy demand for Edison lamps, and to take care of the new developments in Gem, Tantalum and Tungsten lamps, the General Electric Company have in the past year built four new factories at East Boston, Toledo, O., Fort Wayne, Ind., and Newark, N. J. The factory at Toledo is confined to the production of Gem filament lamps only. That of the Newark factory to Tungsten lamps only, and the factories at East Boston and Fort Wayne to the regular carbon filament lamps. In addition, the General Electric Company has erected a new factory building at Harrison, N. J., adjoining the present lamp factory, which is devoted to the production of Tungsten lamps. In addition to these new factories the main factory at Harrison, N. J., continues its large output of carbon and Gem filament lamps. The total productive facilities of the General Electric Company now aggregate sixty million lamps per year, so that they are in excellent position to supply all demands from customers.

The next convention of the National Electric Light Association will be held in Chicago, May 19th to 22nd. The sessions will be held in the Fine Arts Building, with headquarters at the Auditorium Hotel.

SINGLE-PHASE ELECTRIC RAILWAYS.*

M. N. Blakemore.

Much information has appeared from time to time in various technical journals, giving data as to the advances that have been made in the single-phase railway field, but nowhere has there appeared a concise, comprehensive statement of what has actually been accomplished. It is to fill this gap that the writer has been prompted to gather this information together and present it in condensed form. It is interesting to note the rapid strides which this phase of the art has taken since it first appeared commercially in 1903. It may cause some surprise when it is stated that one company alone has already filled orders for more than fifty locomotives, all of which were designed for operation on single-phase alternating current, while of this number considerably more than half were adapted for both alternating and direct current.

In addition to the locomotives indicated in the table, several other special ones have been built for operation on alternating current. Of these might be mentioned the 135-ton single-phase locomotive for the Westinghouse Inter-Works Railway, and the 70-ton 15-cycle alternating-current locomotive which is now being tested by the Pennsylvania Railroad.

All of the installations mentioned are operated from a single catenary trolley, with the exception of the New Haven road, which uses the double catenary line construction. The pantagraph trolley is almost exclusively used in this country, although a sliding bow trolley, somewhat similar to that so common abroad, has been tried, but is not so successful as the pantagraph type of trolley. This is due to the fact that the sliding bow trolley does not respond so readily to the varying heights of wire as does the pantagraph trolley.

*The Electric Journal.

Summary.

Total number of Roads	MILEAGE			Total number of Cars	Total number of Locomotives	Total h. p. of motors employed
	Total	In Operation	Under Construction			
28	966.3	691.8	274.5	240	57	137,400

The table is prepared from data secured through the courtesy of the Westinghouse and General Electric Companies, and contains much information regarding the roads in this country equipped with single-phase apparatus. The main features of the table are given in the summary. In the table, the mileage given is simply the length of the road, and does not take into account the fact that some may have two, three or four tracks electrified. If an accurate statement could be made, the mileage would be considerably increased.

DATA ON SINGLE-PHASE ELECTRIC ROADS IN AMERICA

NAME OF ROAD	Length (Miles) of Line Electrified	Equipment				Type of Control Used	Line Characteristics		Electric Service Started
		Cars		Locomotives					
		No.	Motors	No.	Motors		Voltage	Cycles	
Westinghouse									
Indianapolis & Cincinnati Traction Co.	116	25	4-100	0		Unit Switch	3300 550	25 D.C.	Dec., '04
Westmoreland Traction Co.	6.6	4	4-50	0		Hand	1200	25	March, '05
San Francisco, Vallejo, Benecia & Napa Valley Ry. Co.	34	2 8	4-75 4-100	0		Unit Switch	3300	25	June, '05
Atlanta Northern Traction Co.	18.2	8	4-50	0		Hand	2200	25	July, '05
Warren & Jamestown Street Ry. Co.	22.5	6	4-50	0		"	3300	25	Aug., '05
Long Island Railroad Co.	5	6	2-50	0		"	2200	25	Sept., '05
Spokane & Inland Ry. Co.	115	21	4-100	6 8	4-150 4-175	Unit Switch	6600 550	25 D.C.	Nov., '06
Erie Railroad Co.	34	6	4-100	0		"	11000	25	Dec., '06
Fort Wayne & Springfield Street Ry. Co.	21.5	4	4-75	0		"	6600	25	Jan. '07
Pittsburgh & Butler Street Ry. Co.	33	11	4-100	0		"	6600 550	25 D.C.	May, '07
New York, New Haven & Hartford Railroad Co.	22	0		35	4-250	"	11000 600	25 D.C.	July '07
Windsor, Essex & Lake Shore Rapid Railway	28	5	2-100	0		Hand	6600	25	Sept., '07
Grand Trunk Railroad Co. (Sarnia Tunnel)	3.5	0		5	3-240	Unit Control	3300	25	Under Const.
Visalia Electric Ry. Co.	23	4	4-25	1	4-125	"	3300	15	" "
Chicago, Lake Shore & So. Bend Ry. Co.	78	24 4	4-125 2-75	0		Unit Switch Hand	6600 575	25 D.C.	" "
Denver and Interurban Railway Co	46	10	4-125	0		Unit Switch	11000 575	25 D.C.	" "
Hanover & York Street Ry. Co.	20	5	4-75	0		"	6600 575	25 D.C.	" "
Shore Line Electric Ry. Co.	12	4	4-75	0		"	6600	25	" "
Maryland Electric Ry. Co.	24	9	4-100	0		"	6600	25	" "
General Electric									
Bloomington, Pontiac & Joliet Ry. Co.	19	2	4-75	0		K	3300	25	In Operation
Toledo & Chicago Ry. Co.	43	7	4-75	0		K	3300 575	25 D.C.	" "
Milwaukee Electric Ry. & Light Co.	59	11	4-75	0		M	3300 575	25 D.C.	" "
Central Illinois Construction Co.	80	20	4-75	1	4-150	M	3300 575	25 D.C.	" "
Richmond & Chesapeake Bay Ry. Co.	15	4	4-125	0		M	6600	25	" "
Anderson Traction Co.	20	3	4-75			K	3300 575	25 D.C.	" "
Washington, Baltimore & Annapolis Ry. Co.	60	21	4-125	0		M	6600 575	25 D.C.	Under Const.
New York, New Haven & Hartford R. R. Co.	8	4 2	2-125 4-125			M	11000	25	" "
Shawinigan Railway Co.		0		1	4-150	M	6600 600	30-15 D.C.	" "

Consul Thomas H. Norton, of Chemnitz, reports that by the Slaby-Arco system of wireless telegraphy, over 1,000 words were recently telegraphed from the trial station of the company at Nauen, near Berlin, to the Austrian military station for wireless telegraphy at Korneuberg, near Vienna, a distance of about 372 miles. He adds that this is the record result thus far in the use of the system for overland transmission.

NEWS NOTES

TRANSMISSION.

Petaluma, Cal.—The California Gas & Electric Corporation will commence on a $2,000 electric power plant on the Whitney Block in this city.

Bakersfield, Cal.—It is learned that the next Edison Electric Company's power plant on the Kern River is to be commenced in August. The new power plant will be built in the canyon above Kernville, and will be larger than the present plant.

Oroville, Cal.—The Northern California Mining Company is perfecting plans for two power plants, which will utilize the water of Fall River, a branch of the middle fork of the Feather River, and will be located in the Mooretown district, about 40 miles above Oroville. At one place, a fall of 1,000 feet can be secured, with a minimum flow of 2,000 miners' inches of water. According to the United States Geographical Survey, the falls of Fall River have a drop of 475 feet.

Imperial, Cal.—The closing of the gates of the Holton Power Company's canal, in obedience to restraining orders issued by Judge Wellborn, resulted in the cutting off of electricity from all parts of the valley. Chief Engineer Herrmann, of the California Development Company, believes the result of the restraining order will be the earlier building of a dam in the Alamo River, and a conduit system to take water from below the power house for use in irrigation. The estimated cost of this work is $225,000. The worst inconvenience will be that of lights. At Brawley, preparations are being made to install gasoline engines for the domestic water supply. The Southern Pacific Company has ordered a steam engine rushed to Imperial to pump water into its tanks.

Chihuahua, Mexico.—The Kansas City, Mexico and Orient Railroad Company is planning for the construction of an immense hydro-electric power plant on the El Fuerte River, in Sinaloa, not far west of the Chihuahua State line. The plan is to build a plant that will develop 5,000 or 6,000 horsepower by utilizing the water power of that stream, and use the electric power in the construction of the Orient Railroad as it proceeds eastward through the worst part of the Sierra Madre Mountains, and sell it to the mines in that section. A. M. Nelson, the engineer and superintendent of construction of the Orient in Mexico, is now on the El Fuerte River making the surveys necessary to making a report on the advisability of the plan. The company is said to have bought up what is known as the O'Gorman concession for water power on that river. It is claimed that 10,000 horsepower can be had there.

INCORPORATIONS.

Salinas, Cal.—The American Petroleum Company has been incorporated by Los Angeles men with a capital stock of $1,000,000.

San Francisco, Cal.—The Sparks Mineral Water Company has been incorporated, with a capital stock of $10,000, by L. W. Martin, P. D. La Montanya and W. H. Fisher.

Bakersfield, Cal.—The Ubertas Oil Company has been incorporated by C. L. Metzger, Fritz Boehmer, A. B. Fowler, H. M. Whitely and J. L. Gould. The capital stock is $100,000.

Bakersfield, Cal.—Articles of incorporation have been filed by the State Oil Company. The capital stock is $100,000, and the directors are D. J. Graham, E. W. Rice and W. E. Colby.

Fresno, Cal.—H. E. Barnum, E. J. Boust, H. C. McKay and S. L. Hogue have filed articles of incorporation for the Fresno-Midway Land & Oil Company, with a capital stock of $25,000.

San Francisco, Cal.—The Enterprise Electric Works has been incorporated, with a capital stock of $24,000, by Frank Jones, G. E. Roe, Bertha Roe and Mary E. Jones. Place of business is San Francisco.

Ukiah, Cal.—Articles of incorporation have been filed by the Willits Oil Development Company, with a capital stock of $50,000. The incorporators are A. J. Muri, W. Seyfarth, Bren Schow, E. F. De Camp and Chas. Tuck.

San Francisco, Cal.—Articles of incorporation have been filed by the Sesnon Oil Company, with a capital stock of $100,000. The incorporators are W. E. Knowles, W. T. Sesnon and J. J. Fagan. Place of business is San Francisco.

Oakland, Cal.—Articles of incorporation have been filed by the San Francisco & Bay Counties Railway, which plans to operate an electric railroad between Oakland and San Jose in opposition to the Southern Pacific. F. M. Smith, F. C. Havens, E. A. Heron, George E. Pratt and Dennis Searles are named as directors of the new railway. Within ninety days the actual laying of tracks will commence. The terminus of the line will be at the Key Route pier by the way of Berkeley. The proposed electric line will commence at Berkeley and skirt the Berkeley hills, touching at Piedmont. The company is capitalized at $250,000, of which $70,000 has been subscribed.

TELEPHONE AND TELEGRAPH.

Elko, Nev.—Manager Thomas, who is superintending the construction of a telephone line between Salt Lake City and Elko, to connect the Utah cities with those of the Pacific Coast, reports that the work is in progress this side of the Utah-Nevada State line and the line is following the route of the Western Pacific Railway.

Los Angeles, Cal.—The Home Telephone Company, which five years ago obtained a franchise under the Broughton act, then newly passed by the Legislature, has paid into the city treasury the sum of $14,588.71, representing 2 per cent of its gross earnings during the past year. The sum is the largest received by the city under the terms of the act.